Specifications for MIPP readout electronics back end communication

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Abstract

This document describes the information that needs to be exchanged between the back end readout electronics and the various detector front end electronics for each event. Of course some of the data blocks will be detector specific. The overall communications protocol, data cable, types of triggers, event time stamping, etc. will be uniform for all detectors.

General requirements for MIPP experiment readout

The MIPP experiment in the Fermilab fixed target area measures particle production properties using spills of slow extraced beam from the Main Injector. The experiment typically receives four seconds of beam in two minute intervals. During the four seconds of beam data needs to be recorded with a rate of ~3 kHz. Some calibration (pedestal) data is recorded between spills.

For each triggered event the final trigger decision will be formed within 2 micro-seconds of the interaction time (T_0). The readout of each MIPP detector has to be pipe-lined to allow for this trigger latency. The total number of triggers in a 4 second spill will average 12,000. The limiting factors are TPC readout speed and maximum usable beam intensity. However, the instantaneous rate may be higher. The minimum time between triggers should be designed to be no more than 16 micro-seconds.

All event data needs to be held in the front end electronics until the end of spill and then read out within 54 seconds of the end of spill. The total number of events each front end must be able to hold must be 20,000. These specifications allow flexibility in the beam spill structure, for example to have six second spills or have a repetition rate faster than one spill per two minutes.

Maximum trigger latency	2 µsec
Minimum time between events	16 µsec
Maximum spill length	6 seconds
Maximum readout time after spill	54 seconds
Maximum number of events per spill	20,000

Trigger encoding and event timing – 16 bit trigger word

The Main Injector rf is 53 MHz. This results in an observable beam structure with a period of 18.9 ns at MIPP. This rf will be used to time-stamp events. At the beginning of each spill (on a *trig-spill-begin* trigger) each front end card on each detector will reset the local rf counter. The lower 10 bits of this counter will be used as a time stamp for each event data packet. During readout of the front-ends (after each spill) the time stamps will be checked for consistency and any errors will be reported. 10 bits correspond to 19.3536 µs. In the data each front-end card will report a sequential event number for each event. This event number will not be transmitted in the trigger word.

The trigger word will have a total length of 16 bit, leaving the high 6 bits to encode the trigger type. The list of trigger types is given in the table. 32 of the 64 different trigger types are reserved for event triggers that trigger physics event data. The other 32 trigger types are reserved for special triggers like *trig-spill-begin*, *trig-spill-end*, *trig-run-begin*, *trig-run-end*, *trig-reset*, etc.

Trigger#	bits	Description	Trigger#	bits	Description
0	000000	*Beam (T00 ● T01)*	31	100000	*trig-reset*
1	000001	*T01*	33	100001	*trig-run-begin*
2	000010	*T00*	34	100010	*trig-run-end*
3	000011	*-reserved-*	35	100011	*trig-subrun-begin*
4	000100	*Beam Pion*	36	100100	*trig-subrun-end*
5	000101	*Beam Kaon*	37	100101	*trig-spill-begin*
6	000110	*Beam Proton*	38	100110	*trig-spill-end*
7	000111	*-reserved-*	39	100111	*trig-interspill-begin*
8	001000	*Pion with Interaction*	40	101000	*trig-interspill-end*
9	001001	*Kaon with Interaction*	41	101001	
10	001010	*Proton with Interaction*	42	101010	
11	001011	*Interaction (no beam required)*	43	101011	
12	001100	*Raw pulser*	44	101100	
13	001101	*Interspill pulser*	45	101101	
14	001110	*-reserved-*	46	101110	
15	001111	*-reserved-*	47	101111	
16	010000	*low p Beam (T00_delay ● T01)*	48	110000	
17	010001	*-reserved-*	49	110001	
18	010010	*-reserved-*	50	110010	

19	010011	-reserved-	51	110011	
20	010100	Low p Beam Pion	52	110100	
21	010101	Low p Beam Kaon	53	110101	
22	010110	Low p Beam Proton	54	110110	
23	010111	-reserved-	55	110111	
24	011000	Low p Pion with Interaction	56	111000	
25	011001	Low p Kaon with Interaction	57	111001	
26	011010	Low p Proton with Interaction	58	111010	
27	011011	-reserved-	59	111011	
28	011100	unused	60	111100	
29	011101	unused	61	111101	
30	011110	unused	62	111110	
31	011111	unused	63	111111	

The readout for each detector will perform identical operations for each of the lower 32 trigger types, i.e. perform a full readout of the detector. The distinction between these trigger types is important for the physics interpretation of the data. It is not relevant for the electronics.

The higher 32 trigger types trigger special actions and will not necessarily read out the detector. Some of these special triggers initialize and set the state of the readout electronics. Other special triggers will read out scalers at the end of spill.

The special triggers that are not specified in this version of this document may be used for communication between front end and back end ('send the data for the next buffered event', ...).

Communications link between detector front end cards and readout back end

The detector readout cards will be read out through daisy chains of CAT-4 (or better) network cable with RJ-45 connectors. This section will be written by Sten Hansen.

Summary

This document lists trigger types for the MIPP experiment and some specifications for the readout common to all detectors. This document needs to be expanded to include full details.